Evaluation of Tofu Firmness Using Compression and Indentation Methods

Application Report

General

Recent studies have shown a relationship between mechanical testing of food, called texture profile analysis (TPA) and the texture of food. TPA measures such parameters as chewiness, gumminess, cohesiveness and firmness. Not only do these tests quantify the texture of the food, but it also evaluates the consistency of the manufacturing processes. The purpose of this testing was to evaluate and compare firmness between three different tofu varieties using two different testing methods - a compression method and an indentation method.

TPA Testing

The tests were performed on an Instron® 3345, equipped with a 50 N load cell and Merlin™ software with the TPA calculations module. For the compression method, a 6 in diameter compression platen was positioned at the base of the system and a 1 in diameter compression platen was positioned at the crosshead. For the indentation method, the 2 in diameter platen was replaced with a quarter inch diameter probe. The specimen was placed on the lower platen and the upper platen was lowered to a position just above the height of the sample. The Merlin™ software was programmed to move the crosshead at a speed 50 mm/min until a preload of 0.01 N was achieved. At that point the exact height of the specimen was measured, the testing speed increased to 300 mm/min and data collection began. The test ended when a value of 50% compression was reached.

Samples

The tofu samples consisted of a single solid block. For the compression method, 1 in diameter cylinders of tofu were cored from each of the samples. The bottom portion of the specimen was removed such that a cylinder with a height of approximately 13 mm was used for testing. For the indentation method, a 13 mm thick layer was removed from the bottom of the block.

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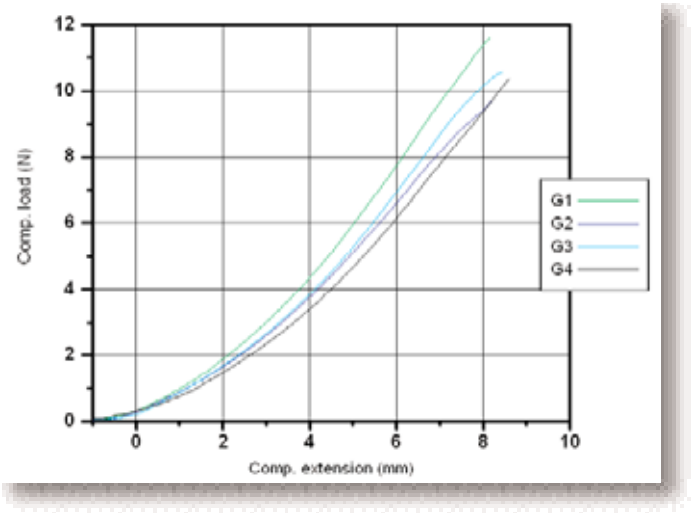
Figure 1:
Test configuration for compression method with 1 in diameter tofu specimen

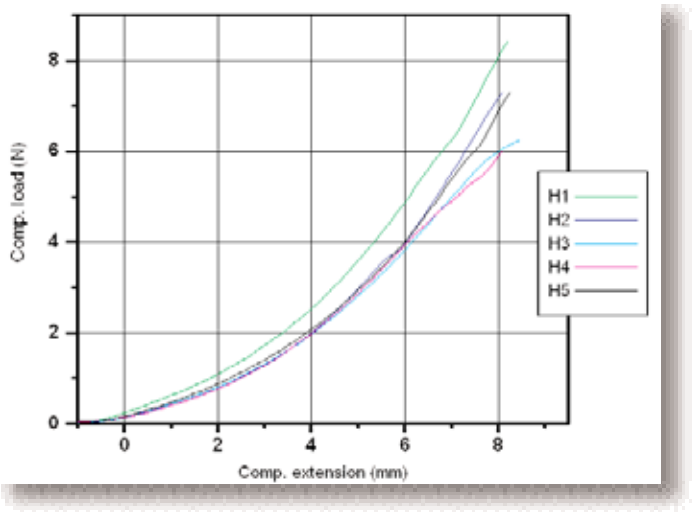
▲
Figure 2:
Test configuration for indentation method with tofu sample in container

Results From Compression Method



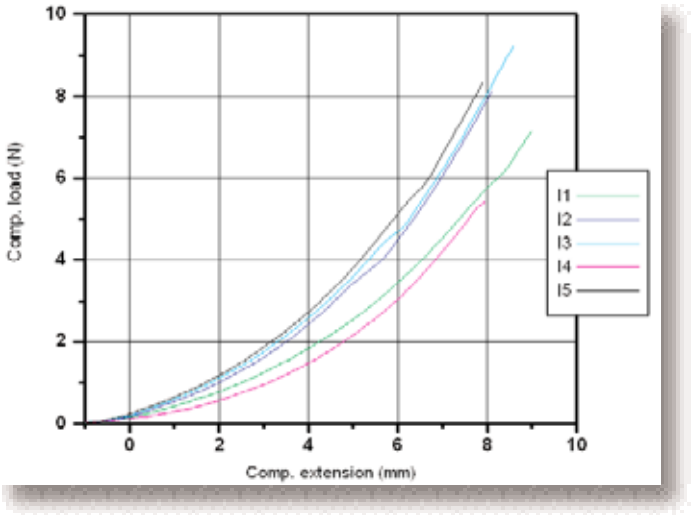
Sample Number	Firmness (N)	Firmness at 5 mm (N)
1	11.62	5.51
2	9.79	4.69
3	10.58	5.04
4	10.38	4.52
Mean	10.59	4.94
S.D.	0.76	0.44

▲
Sample G



Sample Number	Firmness (N)	Firmness at 5 mm (N)
1	8.44	3.27
2	7.33	3.28
3	6.25	3.01
4	6.02	3.33
5	7.33	3.10
Mean	7.07	3.20
S.D.	0.97	0.14

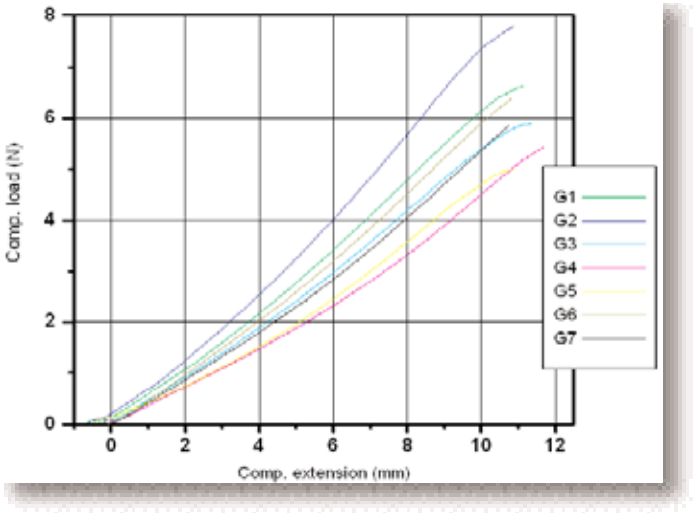
▲
Sample H



Sample Number	Firmness (N)	Firmness at 5 mm (N)
1	7.16	2.75
2	8.14	3.49
3	9.23	3.55
4	5.44	2.90
5	8.35	3.71
Mean	7.66	3.28
S.D.	1.44	0.43

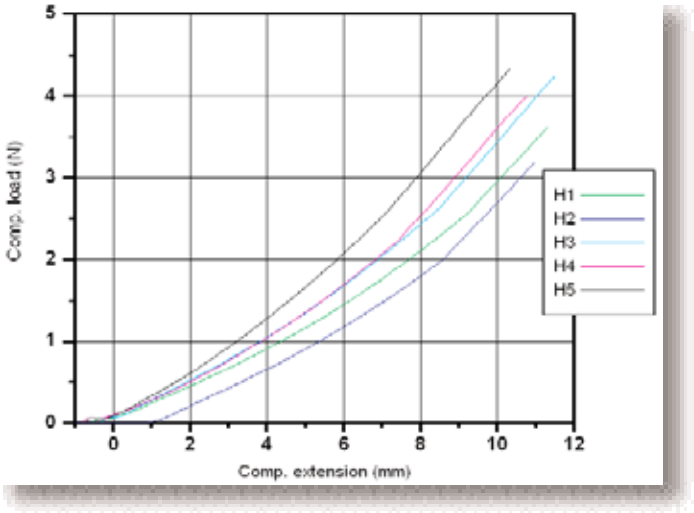
▲
Sample I

Results From Indentation Method



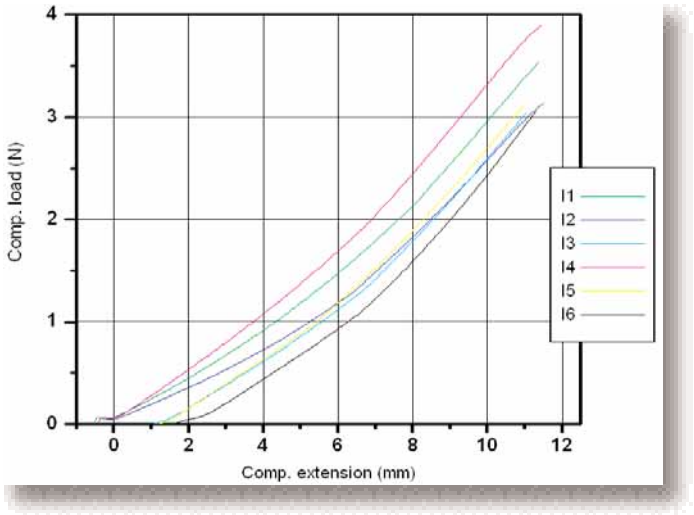
Sample Number	Firmness (N)	Firmness at 5 mm (N)
1	6.62	2.63
2	7.79	3.13
3	5.88	2.40
4	5.43	1.98
5	4.99	1.99
6	6.38	2.69
7	5.86	2.36
Mean	6.14	2.44
S.D.	0.91	0.43

▲ Sample G



Sample Number	Firmness (N)	Firmness at 5 mm (N)
1	3.62	1.25
2	3.19	1.35
3	4.24	1.42
4	3.99	1.49
5	4.33	1.75
Mean	3.87	1.45
S.D.	0.47	0.19

▲ Sample H



Sample Number	Firmness (N)	Firmness at 5 mm (N)
1	3.54	1.32
2	3.14	1.17
3	3.04	1.32
4	3.90	1.41
5	3.14	1.46
6	3.06	1.39
Mean	3.30	1.34
S.D.	0.34	0.10

▲ Sample I

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Conclusions

The Instron® test configuration and software module were successfully able to perform firmness analyses on tofu samples using two different test methods. The following table summarizes the results obtained from both methods, and from these results, several conclusions can be made.

Summary of Results From Firmness Analysis on Tofu Samples - Compression Method

Sample	Mean Firmness (N)	Mean Load at 5 mm Compression (N)
G	10.59 ±0.76	4.94 ±0.44
H	7.07 ±0.97	3.20 ±0.14
I	7.66 ±1.44	3.28 ±0.43

Summary of Results From Firmness Analysis on Tofu Samples - Indentation Method

Sample	Mean Firmness (N)	Mean Load at 5 mm Compression (N)
G	6.14 ±0.91	2.44 ±0.43
H	3.87 ±0.47	1.45 ±0.19
I	3.30 ±0.34	1.34 ±0.10

- Sample G is significantly firmer than Sample H or Sample I
- There is no significant different between firmness in Sample H and Sample I
- It is important to note that there were physical differences in tofu firmness and denseness between the lower and upper half of the tofu block. Therefore, for consistency of results, all tests were conducted on specimens taken from the lower portion of the block. We would expect to see different measures of firmness if samples were taken from other locations and may be an interesting study for future testing.

The test was conducted using two different methods to explore the accuracy and repeatability of each method. The firmness values differ between methods for the same sample because of a difference in sample surface area. Based on standard deviation values, it appears that neither method provides more accurate or repeatable results. It was expected that the platen test with the cored tofu specimen would have provided for more accurate results because edge effects caused by indentation of a probe are neglected.

Configuration Table - Compression Method

Catalog Number	Cofiguration Options	Description
3345	Frame	Single column frame
2519-102	Load Cell	10 lb (50 N) capacity
2501-085	Fixtures	150 mm (6 in) compression platen
2830-005	-	Puncture probe set
2410-257K1	Software	Merlin™ software
2410257D1	-	Compression Application
2410-212	-	TPA Test Method Template

Configuration Table - Indentation Method

Catalog Number	Cofiguration Options	Description
3342	Frame	Single column frame
2519-102	Load Cell	10 lb (50 N) capacity
2501-085	Fixtures	150 mm (6 in) compression platen
2830-036	-	Keyless 3-jaw probe chuck
2830-005	-	Puncture probe set
2410-257K1	Software	Merlin software
2410257D1	-	Compression application
2410-212	-	TPA test method template

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